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Three-dimensional X-ray tomography for multiscale characterization and fatigue damage investigations of composites for wind turbine blades.

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Key mechanical properties of the load carrying composite laminates in wind turbine blades are the stiffness, fatigue resistance and the compression strength. While the overall design criteria for glass fiber composites mainly are stiffness driven, it tends to be more fatigue and compression strength driven when using carbon fiber or glass/carbon hybrids. Using lab-source x-ray computer tomography in connection with ex-situ fatigue testing of quasi uni-directional composites, local fiber failure has been followed. The material investigated is typical non-crimp fabric used in wind turbine blades. The fatigue damage evolutions is studied during tension/tension, tension/compression and compression/compression fatigue. It is found that the location of the tension/tension (R=0.1) and tension/compression (R=-1) fatigue damage are controlled by the bundle architecture, while the compression/compression (R=10) show up as small shear cracks located in the matrix between the fibers. In addition to fatigue damage investigations, the fiber architecture inside the fiber bundle and the fiber bundle architecture is studied. Based on a dictionary based segmentation method, the fiber-architecture inside the fiber bundle is explored. The fiber bundle architecture is studied using more conventional segmentation methods. It is segmentations, which can used as input to multi-scale finite element predictions, e.g. aiming for a predictions of the stiffness and the compression strength reductions due to fiber misalignment and local stress distribution causing fatigue damage due to the architecture of the fiber reinforcement. Three-dimensional X-ray computer tomography large amount of data, typical between 2-50GB from each dataset. During publication, only a small amount of such data set can be shown. Therefore conclusions from such studies can be doubtful, if not the full data-set is made available together with the publication. Strategies for how to do this will be presented at the end of the talk.

Biography:

Lars P. Mikkelsen obtained his PhD in Solid Mechanics in 1995 at the Technical University of Denmark (DTU). After that, he has been a Carlsberg Clare Hall visiting follow at the Cambridge Center for Micromechanics as well as a visiting scholar at Harvard University. Has since 2001 worked at the current geographic location near Roskilde in Denmark, first as a senior scientist at the Material Research Department at the Risø National Laboratory and latest as an associate professor and head of section for the Composite Mechanics and Structure section at the DTU Wind Energy. Has more than 25 years' of experience working with numerical modelling and experimental characterization of materials and structures. In the last 10 years, the work has focused on research in composite materials regarding compression strength and fatigue behavior of the load carrying laminates in wind turbine blades. During

this, technique such as x-ray computer tomography and commercial finite element codes together with user defined user subroutines is used. Organizes onsite and e-learning courses on the master and PhD-level in those fields in addition to supervision of master and PhD students. Have throughout the years published more than 80 papers of which more than 40 is in international journals. Has two patent applications on strain gauges designs for composite testing.